§8. Temperature Effect on Strain Hardening and Fracture Mode of JLF-1 Steel under Static Plastic Deformation

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Development of structure materials for a blanket is one of critical issues for early realization of fusion energy. Material deformation behavior is the important information for the blanket design. Reduced activation ferritic/martensitic (RAF/M) steels are considered to be applied in potential fusion energy systems. Thus, it is necessary to study the temperature effect on strain hardening of RAF/M steels as the strain hardening shows the deformation resistance when the applied stress would exceed the yield stress.

In this work, the tensile tests and microstructure analysis of the RAFM steel, JLF-1, were carried out from RT to 873 K at strain rate of 0.1%/s and 0.02%/s to investigate the material static deformation behavior.

The yield stress (YS) and ultimate tensile strength (UTS) are the important data for design. The change in YS and UTS of JLF-1 steel against test temperature is shown in Fig. 1. The strain rate does not affect the YS and UTS significantly. The difference between YS and UTS decreases significantly above 773 K, which means strain hardening becomes smaller in this temperature region. Especially at 873 K, the UTS of JLF-1 drops to about 300 MPa, very close to the YS.

Fractography oftThe fracture surface of the tensile specimens was performed with scanning electron microscopy (SEM). Cup and cone fracture was observed in the specimens tested at high temperature. Fig. 2 shows the SEM image of fracture surface of the tensile specimen at 673 K. The dimple zone area was measured in Fig. 2, the change in ratio of dimple zone to fracture surface area is shown in Fig.3. Three regions could be defined according to the ratio change.

1) Region A: Around RT, the dimple zone was small.
2) Region B: Below 673 K, the change in ratio was independent on temperature, shear fracture was dominant.
3) Region C: At 773 K and 873 K, the change in ratio was very sensitive to temperature. Dimple fracture was dominant. Thus, little strain hardening was observed in Fig.1 in those temperature region.

From Fig.1 to Fig.3, with strain hardening decreased, the difference between YS and UTS decreased significantly above 773 K; and the fracture mode was changed from shear fracture below 673 K to dimple fracture at 773 K and 873 K. It means that the potential to support the over loading decrease as the temperature rises, and much ductility appears.

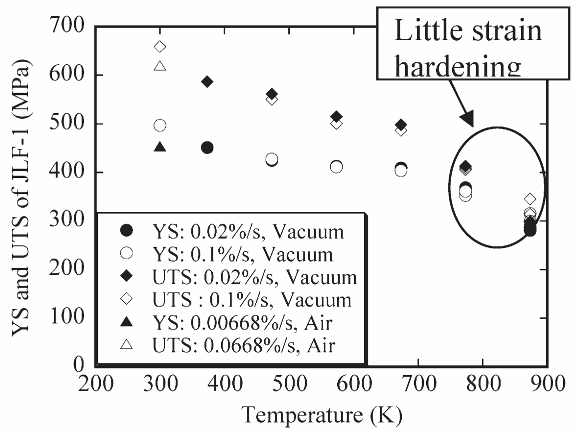

Fig.1 Change in YS and UTS against test temperature.

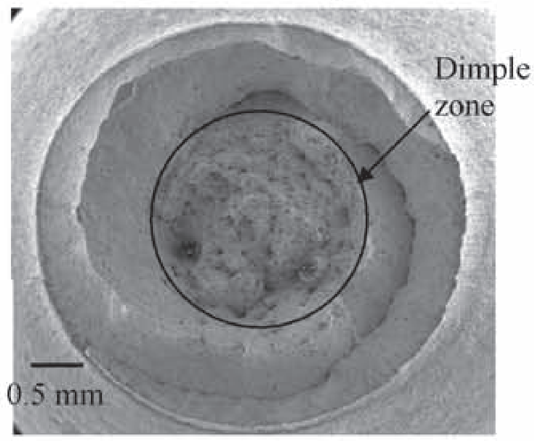

Fig. 2 SEM images of the fracture surfaces at 673 K.

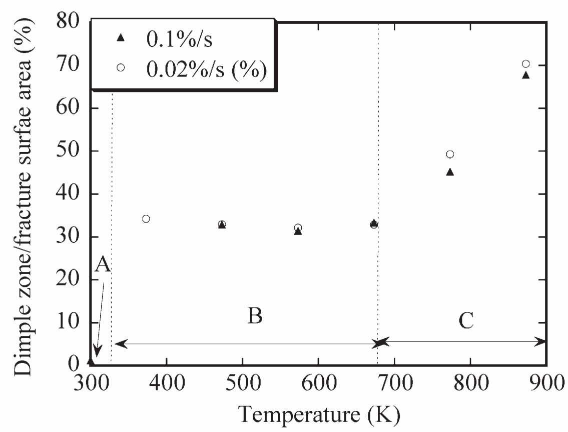

Fig 3 Change in the ratio of dimple zone to fracture surface area against temperature.